

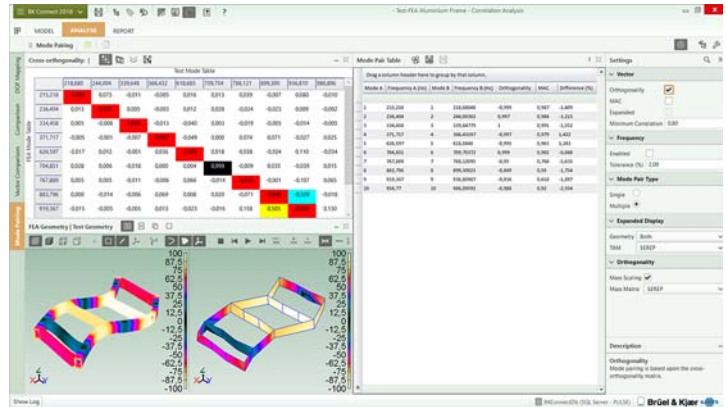
BK Connect Structural Dynamics

## Correlation Analysis Type 8421

### Finite Element Interface Types 8400-D, 8400-E and 8400-F

*BK Connect™ Correlation Analysis is an easy-to-use post-processing application that enables you to correlate two modal models whether they are finite element models or test models. The Finite Element Interfaces software enables you to import finite element models (FEM) from Nastran, Ansys, Abaqus or as UFF files. Accurate correlation is quickly obtained by following an intuitive, yet flexible workflow process that guides you efficiently through geometry alignment, DOF mapping, comparison, vector comparison, mode pairing and reporting.*

*BK Connect Correlation Analysis, Modal Analysis, ODS Analysis, Structural Measurements and/or Advanced Sine Measurements applications constitute an integrated system for modal measurements, ODS analysis, modal analysis and model correlation.*



## Uses and Features

### Uses

- Correlation of two modal models: FEM vs Test, Test vs Test or FEM vs FEM in order to:
  - Evaluate different test and modelling strategies
  - Identify shortcomings in modal tests
  - Identify areas of insufficient finite element (FE) modelling quality
  - Define targets and update variables for model updating
- Test planning using imported finite element analysis (FEA) results
- Import and decimation of FE models to test models to be used for experimental modal analysis
- Integrated solution from measurement to FEM correlation using BK Connect Structural Measurements Type 8411, Advanced Sine Measurements Type 8412, Modal Analysis Type 8420, Modal Analysis (advanced) Type 8420-A and Correlation Analysis Type 8421
- Open, stand-alone application to be used with your existing data acquisition and analysis system

### Features

- Efficient workflow with just a few steps to perform a complete correlation analysis
- Import of test modal models in standard formats

- Import of finite element models from Nastran, Ansys, Abaqus or UFF
- Easy-to-use and powerful test geometry drawing tools using built-in CAD models
- Selection and validation of test nodes from FE models for test planning
- Decimation of finite element models to test models
- Geometry alignment by scaling and orienting the two models
- DOF mapping to match DOFs from the two models
- Comparison of test and FE modal models using mode tables and mode shape animation
- AutoMAC and CrossMAC tables and 3D plots calculated in reduced test space
- Auto-orthogonality and Cross-orthogonality tables and 3D plots calculated in reduced test space
- Import of reduced mass matrix from Nastran or Abaqus
- SEREP algorithm can be used if no reduced mass matrix is available
- Expansion of test modal vectors to FE space using the SEREP algorithm
- Pairing of modes from two modal models according to their degree of frequency correlation, shape correlation or manually
- Integrated Microsoft® Office reporting capabilities

BK Connect is the latest addition to the Brüel & Kjær platform of software products. It provides real-time measurements, analysis and test-FEA integration in a modern, intuitive GUI environment and is the culmination of extensive customer surveys to resolve their most important issues when analysing sound and vibration data.

BK Connect provides:

- Enhanced usability for high productivity with an intuitive user interface that puts the tools you need at your fingertips. The graphical user interface is built around a workflow model that leads you easily through any test setup, measurement and analysis process
- Open data policy that supports a wide range of native and third party formats for improved import and export of data
- Consistent user interface throughout all applications encouraging faster learning of new applications

The BK Connect Structural Dynamics suite allows you to observe, analyse and document the dynamic behaviour of structures using a single software platform covering setup, measurements, analysis and test-FEA integration. With BK Connect Structural Measurements, you can set up and perform single or polyreference hammer and shaker measurements, and with BK Connect Advanced Sine Measurements you can set up and perform SIMO or MIMO stepped sine measurements with closed-loop control, whereas BK Connect Modal Analysis provides accurate and reliable results even in the most demanding situations using a targeted set of best-in-class mode indicator functions, curve-fitters and analysis validation tools.

BK Connect ODS Analysis adds time and spectral ODS measurement and analysis. The time ODS measurements can also be used for operational modal analysis (OMA) in PULSE OMA.

BK Connect Correlation Analysis adds the capability of correlating two modal models, for example, finite element model versus test model using tools such as Geometry Alignment, CrossMAC and Cross-orthogonality calculations.

The open data policy behind the BK Connect Structural Dynamics suite also allows the post-processing applications to be used as stand-alone applications together with your existing measurement and analysis system.

## Geometry

---

BK Connect Correlation Analysis contains powerful tools for working with geometries. It allows you to create test geometries, import test and finite element geometries, decimate finite element geometries to test geometries and align test and finite element geometries.

### **Geometry Creation and Import**

Test geometries can be created from scratch using the embedded drawing tools. You can work with various elements like points, lines, triangular and quad surfaces and you can create various 2D and 3D CAD models and mesh them. The geometry can also be created from table entries. Alternatively, test geometries can be imported in standard data formats like UFF and CSV.

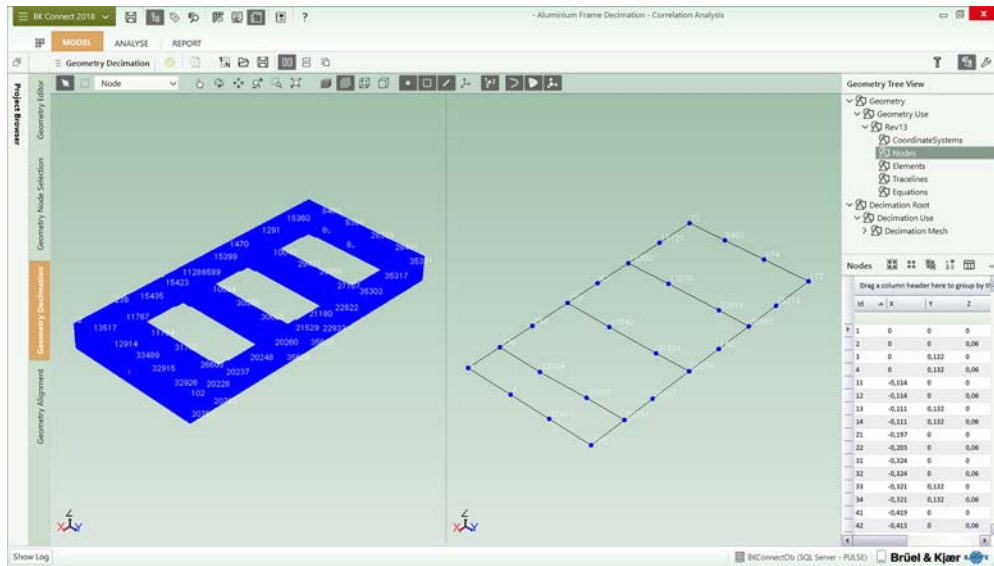
Finite element (FE) models can be imported as UFF files or from Nastran, Ansys and Abaqus. Import of FE models can include, apart from geometry data and modal data, also reduced mass matrices (Nastran or Abaqus). This allows for animation of the FE modes as well as correlation of finite element analysis (FEA) results with test results.

### **Geometry Decimation**

Imported FE geometries can be decimated to test geometries for use in, for example, BK Connect Structural Measurements or BK Connect Advanced Sine Measurements. The decimation can be done graphically by clicking on the nodes of the FE geometry to keep. Lines and optional surface elements like triangles or quads connecting the points, are automatically drawn on-the-fly.

You can also select nodes on a FE model and investigate how the AutoMAC builds up for the reduced geometry consisting of the selected nodes. This helps determine which nodes on the FE model to include in a test geometry to identify and separate modes of interest.

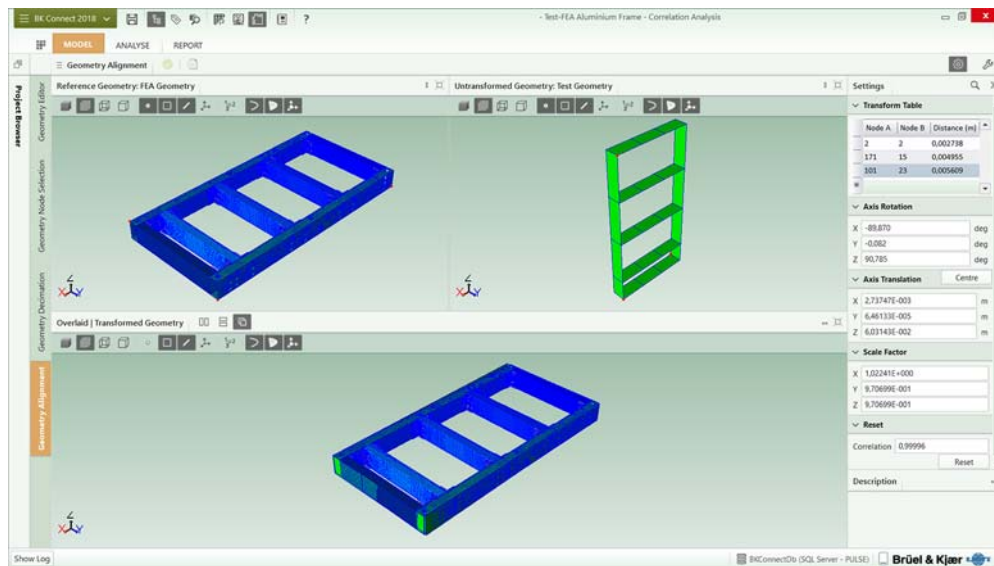
**Fig. 1**  
*Geometry Decimation.*  
 Simple test geometries can easily be created from FE models



### Geometry Alignment

Before two modal models can be correlated, their respective geometries must be aligned in space as regards orientation and scaling. This is obtained by selecting, graphically or using a table, three or more pairs of points to be aligned on the two geometries.

**Fig. 2**  
*Geometry Alignment.*  
 Alignment can be performed by selecting three or more point pairs on the two geometries



## Analysis and Reporting

By logically grouping features and display of results, BK Connect Correlation Analysis allows you to do a complete correlation analysis in just five main steps:

- Geometry Alignment
- DOF Mapping
- Comparison
- Vector Comparison
- Mode Pairing

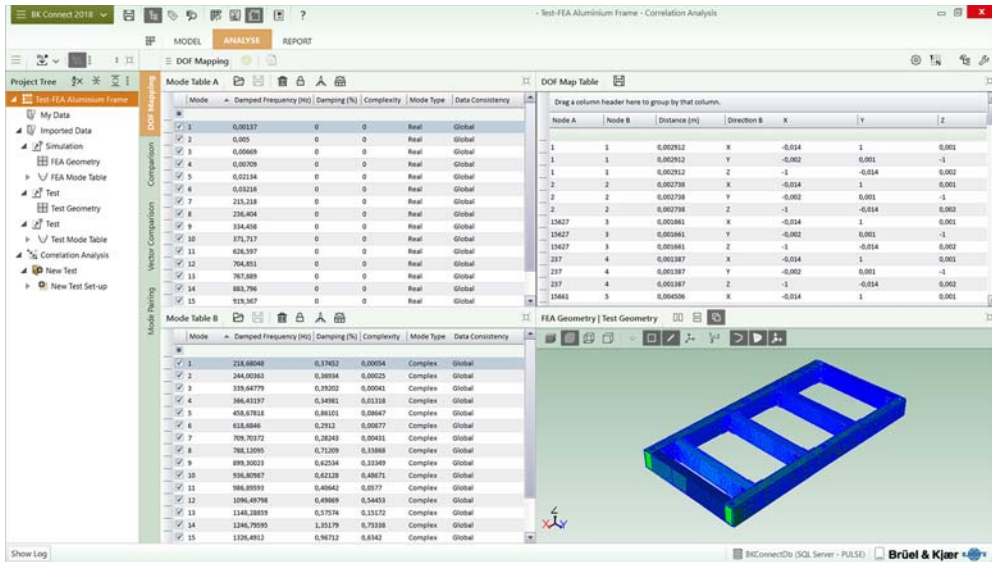
In addition, a User-defined Displays task is available.

Extensive live reporting can be done at any time during the analysis process in Microsoft® Word, Excel® or PowerPoint® using integrated reporting functions.

### DOF Mapping

The nodes and directions of the two models are mapped based on the DOF information in the two mode tables and the geometry alignment previously performed. The distance between the mapped pairs of nodes and the relation between directions on the two models are displayed in a table. Also the two models' geometries and mode tables are shown.

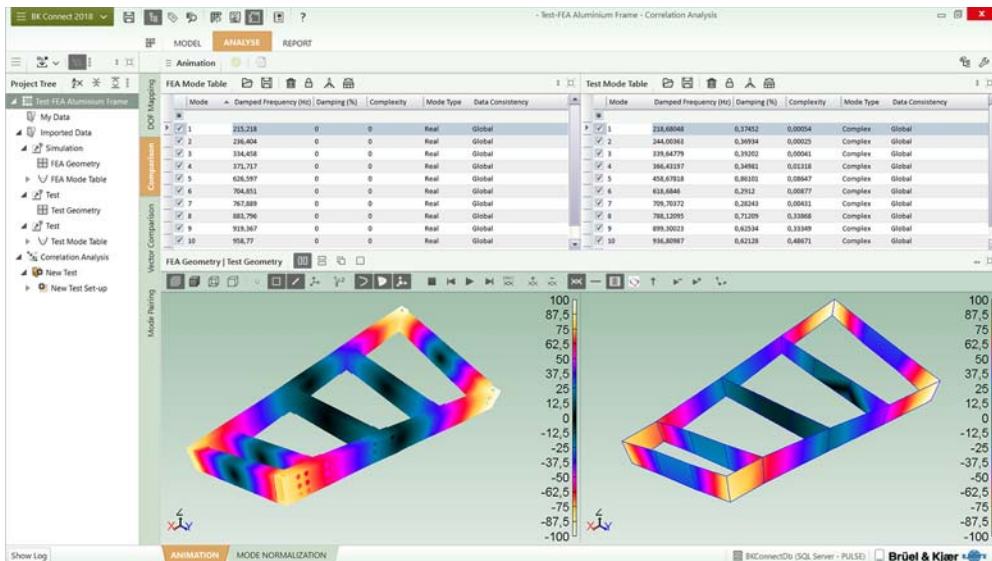
**Fig. 3**  
DOF Mapping.  
Nodes and directions of the two models are mapped



### Comparison

The Comparison task allows you to further investigate the two modal models. This includes mode shape animation, where the two models can be shown in various layouts including side-by-side, top-bottom, overlaid or differenced.

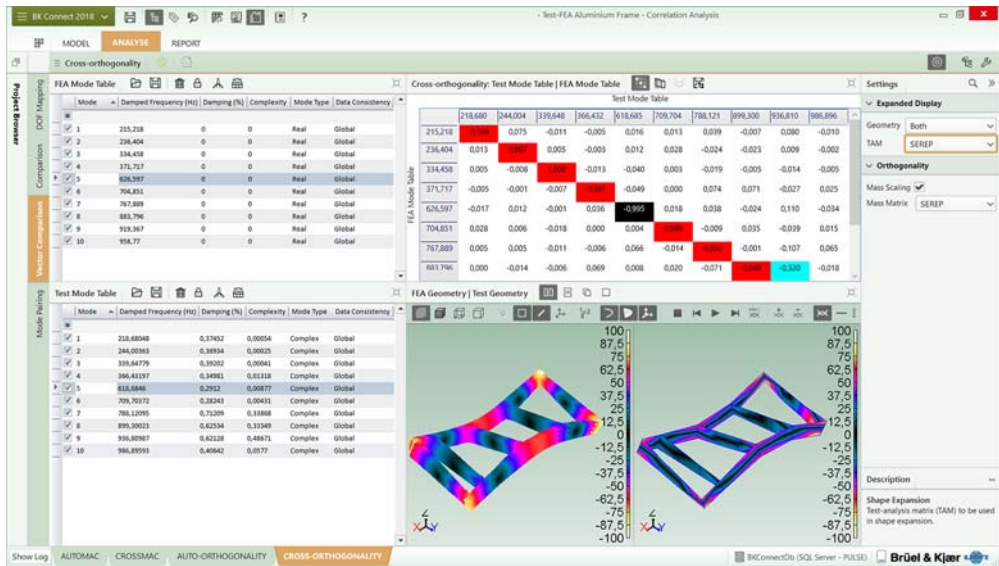
**Fig. 4**  
Comparison.  
Comparing 1st torsional mode from FEA and test



### Vector Comparison

Vector comparison can be done by calculating AutoMAC, CrossMAC, Auto-orthogonality and Cross-orthogonality tables and 3D plots in reduced test space. The Auto-orthogonality and Cross-orthogonality results are calculated using a reduced mass matrix. If a reduced mass matrix does not exist, the SEREP algorithm can be used for orthogonality calculations. Expansion of test modal vectors to FE space can be done using the SEREP algorithm.

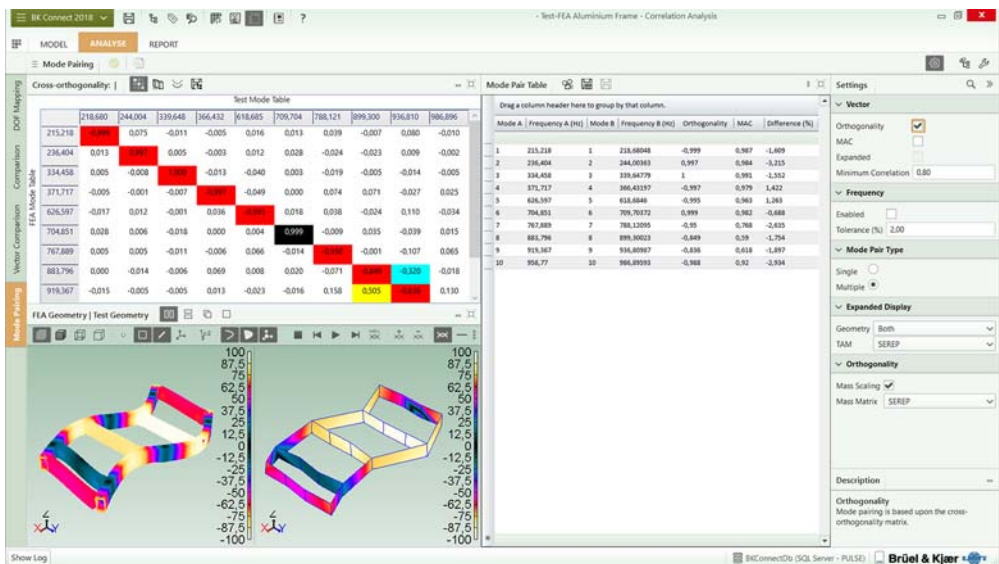
**Fig. 5**  
**Vector Comparison.**  
 Cross-orthogonality comparing the mode shapes found using FEA and test. The mode pair selected is automatically animated



### Mode Pairing

Modes can be paired according to their degree of frequency correlation, mode shape correlation based on CrossMAC or Cross-orthogonality calculations or manually.

**Fig. 6**  
**Mode Pairing.**  
 Pairing the modes from FEA and test based on Cross-orthogonality. Selected FEA-Test mode pair (Mode 10: 372 Hz and Mode 4: 366 Hz) is shown animated



### Reporting

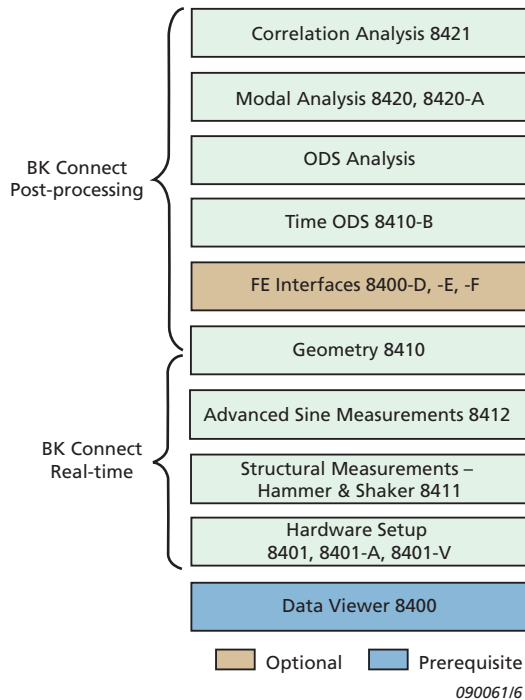
The Report task enables reports to be prepared in parallel with the analysis process, linking important results as they are produced. Store geometries, displays, tables and text in the Project Browser as report elements so when you are ready, you only need to generate and save the report. Generated reports can be based on standard embedded templates, customised templates you define, or on-the-spot.

High-quality, active or static reports are easily created directly in Microsoft® Word, Excel® or PowerPoint®.

### User-defined Displays

The User-defined Displays task enables you to create customized layouts consisting of graphs, geometries (with or without animation), shape tables, MAC tables/plots and complexity plots. Data can be linked between displays in the layout so that source data in one display is reflected in a result display. For example linking a mode table to a geometry – changes to the mode table will be automatically updated in the geometry. This allows for fast and flexible data viewing and ad hoc analysis.

**Fig. 7**  
BK Connect structural dynamics product structure – from setup and measurements to analysis and test-FEA integration



### Core Applications

#### *BK Connect Data Viewer Type 8400*

BK Connect Data Viewer provides the framework, including BK Connect database, Project Browser, reporting, Notes and help system. This module must be installed to run most BK Connect applications.

#### *BK Connect Data Viewer (advanced) Type 8400-A*

Adds a Data Table Viewer, Result Matrix Viewer and Scratchpad Calculator sub-tasks.

#### *BK Connect Hardware Setup Type 8401*

This is a prerequisite for measurements in BK Connect. It provides the Hardware Matrix, the HW Setup Table and Monitor including a built-in monitor recorder as well as the Transducer Manager and Transducer Verification tasks. Up to two LAN-XI data acquisition modules are supported.

#### *BK Connect Hardware Setup (advanced) Type 8401-A*

Adds support of more than two LAN-XI data acquisition modules and Accelerometer Mounting Check, Brüel & Kjær's patented method of validating the mounting of your accelerometers and thus the integrity of the measurement chain.

#### *BK Connect Virtual Hardware Setup Type 8401-V*

This free software makes it possible to set up your hardware without having it connected thereby freeing it up for other purposes.

For more information on BK Connect Data Viewer Type 8400/8400-A, Hardware Setup Type 8401/8401-A and Virtual Hardware Setup Type 8401-V, see product data [BP 0005](#).

## Measurement and Modelling Applications

### *BK Connect Structural Measurements – Hammer and Shaker Type 8411*

Adds dedicated setup and measurements tasks for hammer and shaker testing, including measurements for MIMO analysis. Geometry-guided measurement setup, execution and validation is supported.

### *BK Connect Advanced Sine Measurements Type 8412*

Type 8412 adds dedicated setup and measurement tasks for single and multi-shaker stepped sine testing. Geometry-guided measurement setup, execution and validation is supported.

### *BK Connect Geometry Type 8410*

Geometry allows the importation and creation of geometries and is used across the various BK Connect Structural Dynamics solutions. FE models can be imported using UFF and decimated to test models.

A variety of animation types are supported including wire frame, surface contour, point and arrow animation as well as overlaid, difference, top-bottom, and side-by-side animation in single-, dual- or quad-view format. The animations can be recorded as GIF files or AVIs and included in Word and PowerPoint® reports.

For more information on BK Connect Structural Measurements – Hammer and Shaker Type 8411, Advanced Sine Measurements Type 8412 and Geometry Type 8410, see product data [BP 1524](#).

## Modal and ODS Analysis Applications

### *BK Connect Modal Analysis Type 8420*

An application designed for single-reference modal analysis with a basic, yet comprehensive, set of mode indicator functions (MIFs), curve-fitters and analysis validation tools. For use with single shaker FRF data and single-reference hammer testing data.

### *BK Connect Modal Analysis (advanced) Type 8420-A*

Adds polyreference modal analysis capabilities and advanced MIFs, curve-fitters and analysis validation tools to the Modal Analysis application. For use with shaker MIMO (multiple-input multiple-output) FRF data, polyreference hammer testing data or for advanced analysis and validation of both single and polyreference data.

For more information on BK Connect Modal Analysis Type 8420 and Modal Analysis (advanced) Type 8420-A, see product data [BP 1523](#).

### *BK Connect ODS Analysis*

With Type 8400 and Type 8410 licences installed, a BK Connect ODS Analysis application is available for frequency-based spectral ODS post-processing analysis or for viewing modal analysis results.

BK Connect Time ODS Option Type 8410-B adds a dedicated task for Time ODS analysis. Results can be converted between acceleration, velocity and displacement and shown as peak, peak-peak or rms using SI or imperial units.

For more information on BK Connect ODS Analysis including Time ODS Option Type 8410-B, see product data [BP 0018](#).

## Test-FEA Integration Applications

### *BK Connect FE Interfaces Types 8400-D, -E, -F*

FE Interfaces enable you to import FE models from Nastran, Ansys and Abaqus.

### *BK Connect Correlation Analysis Type 8421*

Correlation Analysis adds the ability to correlate two modal models: FEM vs Test, Test vs Test or FEM vs FEM.

## Complete Measurement Chain

---

With Brüel & Kjær's complete and fully integrated measurement chain, including accelerometers, impact hammers, force transducers, modal exciter systems, data acquisition front ends and measurement and post-processing software, you can select the optimal solution for your structural dynamics needs. The openness and flexibility of BK Connect Structural Dynamics applications support your needs today and in the future. You are never limited to a vendor-specific system configuration and can easily assemble the system of your choice.

Correlation of two modal models with Cartesian coordinate systems

### SYSTEM REQUIREMENTS

- BK Connect 2018.1 or later
- The following BK Connect applications:
  - Data Viewer Type 8400
  - FE Interfaces Types 8400-D, -E, -F to import Nastran, Ansys and Abaqus models and results, respectively
  - Geometry Type 8410 for all geometry functionality
- Microsoft® Windows® 10 Pro or Enterprise (x64) with either Current Branch (CB) or Current Branch for Business (CBB) servicing model; or Windows® 7 Pro, Enterprise or Ultimate (SP1) (x64) operating systems
- Microsoft® Office 2016 (x32 or x64) or Office 2013 (x32 or x64)
- Microsoft® SQL Server® 2014 Express (SP2) (included in installation), SQL Server® 2014 (SP2), SQL Server® 2012 R2, SQL Server® 2008 or 2008 R2 Express Edition SP1

### RECOMMENDED PC FOR USE WITH FE MODELS

- Intel® Core™ i7, 3 GHz processor or better
  - 32 GB RAM
  - 480 GB Solid State Drive (SSD) with 20 GB free space, or better
  - 1 Gbit Ethernet network\*
  - Microsoft® Windows® 10 Pro or Enterprise (x64), CB
  - Microsoft® Office 2016 (x32)
  - Microsoft® SQL Server® 2014 (SP2)
  - Screen resolution of 1920 × 1080 pixels (full HD)
- This will support test-FEA correlation analysis of FE models up to 1 M nodes

## Geometry

### GEOMETRY CREATION AND EDITING

- Basic geometries using nodes, trace lines, triangle and quad elements
- Geometries based on built-in CAD models:
  - Curves: Circle, Circular Arc, Ellipse, Elliptical Arc, Hyperbolic, Parabolic, Line, Polyline, Interpolation Spline and Control Points Spline
  - Surfaces: Circular, Circular Arc, Ellipse, Elliptical Arc, Hyperbolic, Parabolic, Triangular, Rectangular, Polygon, Interpolation Spline and Control Points Spline
  - Solids: Cylinder, Hemisphere, Sphere, Box, Cone and Conical Frustum
- CAD models with selectable colour and transparency
- Move (translate, rotate) and copy (linear, radial) operators for CAD models and meshes using interactive handles or manual entry
- Definition of locations with three directions on a CAD model (Sites)
- Meshing of CAD models
- Extrusion of CAD models: Curves can be extruded to surfaces. Plane surfaces can be extruded to solids. Preselection of colour is possible
- Hierarchical geometry tree view with subfolders for Coordinate Systems, Nodes, Elements, Trace Lines and Equations
- Tables for Coordinate Systems, Nodes, Elements, Trace Lines and Equations with sorting, filtering, multiple selection and editing
- Support of Cartesian, Cylindrical and Spherical coordinate systems. Local and Global coordinate systems
- Automated point numbering. Partial or complete semi-automated point renumbering
- Visual link between sections made in the geometry display and Geometry Tree

### GEOMETRY IMPORT FORMATS

UFF data set types 15, 18, 82, 2411, 2412, 2416 or 2431; Microsoft® Excel® (\*.csv); UFF FE models; Nastran (MSC, NX, NEI), Ansys and Abaqus FE models (requires Type 8400-D/E/F)

### GEOMETRY EXPORT FORMATS

UFF data set types 15, 18, 82 or 2412 and Microsoft® Excel® (\*.csv)

### NODE SELECTION

Select test node locations on a FE model until a satisfactory FE AutoMAC is created.

A-set nodes from an imported Reduced Mass Matrix or Reduced Stiffness Matrix from MSC Nastran (.op2) are automatically selected for validation and potential modification.

Nodes selected are automatically highlighted in the Geometry Decimation task for connection with trace lines and/or elements

### DECIMATION

Imported FE models can be decimated to test models by manually selecting nodes on the FE model or by entering the nodes directly in a table. Selected nodes can be connected with trace lines and/or elements

### ALIGNMENT

Two modal models can be aligned as regards orientation and scaling using three or more node pairs. Graphical and tabular methods available

### DYNAMIC POINT NUMBERING

Show more point numbers (IDs) when zooming in on parts of the geometry (user-definable). Also supported during animation

### GEOMETRY VIEWS

- Single, Side-by-Side, Top-Bottom and various Quad views
- Definition of front, back, left, right, top and bottom view axis
- Isometric view
- Perspective, orthographic and stretched projections of geometry
- Hidden lines and transparency
- Pan, zoom and rotate options for viewing geometries
- Symbols for shaker, impact hammer, force transducer and accelerometer positions shown on geometry with customized colours and sizes

### CUTTING PLANES

Cut through a geometry in three user-defined 2D planes to view the interior or exclude viewing parts of the geometry. Also supported during animation

### ANIMATION

- Deformed and undeformed animation with Max. Deformation
- Single, overlaid and difference animation
- Wireframe, contour (solid, solid edge), point and arrow animation
- Animation of non-measured DOFs using interpolation equations
- AVI file generation with selectable codec

### DOF Mapping

- Map DOFs from two aligned geometry models, their mode shape tables and DOF node and DOF direction tolerances
- Mapped DOFs shown with resulting node distance and direction relationship
- Nodes on Geometry B (typically a test geometry) can be re-numbered to the same node IDs as the nodes on Geometry A (typically a FE model)

### Comparison

General comparison of two modal models. Mode tables contain the modal models in terms of natural frequency, damping and mode shapes. Comprehensive documentation of modal results including:

- Mode number, Mode Description, Estimation Method, Mode Complexity, Mode Type, Mode Shape Scaling, etc.
- Columns with Sorting and Filtering

Selected mode pairs are automatically animated

\* A dedicated data acquisition network (LAN or WAN) is recommended; a network that only handles data from the front end improves the stability of the data



## Vector Comparison

Vector (mode shape) comparison of two modal models:

- AutoMAC, CrossMAC, Auto-orthogonality and Cross-orthogonality with animation of selected mode pairs
- AutoMAC and CrossMAC tables and 3D plots calculated in reduced test space
- Auto-orthogonality and Cross-orthogonality tables and 3D plots calculated in reduced test space
- Import of Nastran or Abaqus reduced mass matrix. SEREP algorithm can be used if reduced mass matrix is not available
- Expansion of test modal vectors to FE space can be done using the SEREP algorithm

## Mode Pairing

- Pairing of modes from two modal models according to their degree of:
  - Frequency correlation
  - Mode shape correlation based on CrossMAC or Cross-orthogonality calculations
  - Manual pairing

## Ordering Information \*

### Type 8421-X BK Connect Correlation Analysis

#### PREREQUISITE SOFTWARE

Type 8400-X	BK Connect Data Viewer
Type 8410-X	BK Connect Geometry

#### SOFTWARE FOR FINITE ELEMENT MODEL SUPPORT

Type 8400-D-X	BK Connect Nastran Interface
Type 8400-E-X	BK Connect Ansys Interface
Type 8400-F-X	BK Connect Abaqus Interface

#### Maintenance and Support

M1-8400-X	Software Maintenance & Support for Type 8400
M1-8400-A-X	Software Maintenance & Support for Type 8400-A
M1-8400-D-X	Software Maintenance & Support for Type 8400-D
M1-8400-E-X	Software Maintenance & Support for Type 8400-E
M1-8400-F-X	Software Maintenance & Support for Type 8400-F
M1-8410-X	Software Maintenance & Support for Type 8410
M1-8410-B-X	Software Maintenance & Support for Type 8410-B
M1-8411-X	Software Maintenance & Support for Type 8411
M1-8411-XS	Software Maintenance & Support for Type 8411-S
M1-8411-A-XS	Software Maintenance & Support for Type 8411-A-S
M1-8412-X	Software Maintenance & Support for Type 8412
M1-8420-X	Software Maintenance & Support for Type 8420
M1-8420-A-X	Software Maintenance & Support for Type 8420-A
M1-8420-XS	Software Maintenance & Support for Type 8420-S
M1-8420-A-XS	Software Maintenance & Support for Type 8420-A-S
M1-8421-X	Software Maintenance & Support for Type 8421

- Mode Pair table includes
  - Mode number, frequency and damping for each mode
  - Cross-orthogonality, CrossMAC and Frequency Difference (%) for each mode pair
- Animation of selected mode pairs

## User-defined Displays

For user-specific definition of layouts.

Supports geometries with animation, function data, tables (DOF pairing, mode pairing, mode shapes, MAC and Orthogonality), plots (Complexity, MAC and Orthogonality), etc.

## Reporting

Integrated live reporting using Microsoft® Word, Excel® and PowerPoint®.

Reports can be prepared in parallel with the analysis process and generated at any time

### BK Connect Structural Dynamics Suite

#### SOFTWARE

Type 8400-A-X	BK Connect Data Viewer (advanced)
Type 8410-B-X	BK Connect Time ODS Option
Type 8411-X	BK Connect Structural Measurements – Hammer and Shaker
Type 8412-X	BK Connect Advanced Sine Measurements
Type 8420-X	BK Connect Modal Analysis
Type 8420-A-X	BK Connect Modal Analysis (advanced)

#### PACKS

Type 8411-XS	BK Connect Structural Measurements and Analysis Pack
Type 8411-A-XS	BK Connect Structural Measurements and Analysis Pack (advanced)
Type 8420-XS	BK Connect Modal Analysis Pack
Type 8420-A-XS	BK Connect Modal Analysis Pack (advanced)

\* "X" indicates the licence model, either N: Node-locked or F: Floating

Brüel & Kjær and all other trademarks, service marks, trade names, logos and product names are the property of Brüel & Kjær or a third-party company.

Brüel & Kjær Sound & Vibration Measurement A/S  
DK-2850 Nærum · Denmark · Telephone: +45 77 41 20 00 · Fax: +45 45 80 14 05  
[www.bksv.com](http://www.bksv.com) · [info@bksv.com](mailto:info@bksv.com)  
Local representatives and service organizations worldwide

Although reasonable care has been taken to ensure the information in this document is accurate, nothing herein can be construed to imply representation or warranty as to its accuracy, currency or completeness, nor is it intended to form the basis of any contract. Content is subject to change without notice – contact Brüel & Kjær for the latest version of this document.

**Brüel & Kjær** 

